

no reason to think that any displacement of investment is occurring, and thus no reason to use the higher discount rate. If the BCM were using the shadow price of capital approach, the discount rate would be the CRTP (the Treasury rate of 4 percent), and none of the costs or benefits would be multiplied by the shadow price of capital because none displaces private investment. By the same logic, none of the costs and benefits should logically be subject to the 7 percent rate that represents the return on private capital.

Deriving the Treasury Rate

The preceding discussion uses 4 percent as the Treasury cost of borrowing, but that is a simplification. Instead of a single Treasury borrowing rate, Circular A-94 includes two tables, giving nominal and real interest rates for Treasury debt of various maturities. (See Appendix C, reprinted below.)

In theory, nominal long-term rates should reflect more uncertainty about future inflation, whereas real rates should be relatively stable over different terms. In fact, however, OMB's real rates show a slightly more exaggerated term structure (from 3.1 percent at 3 years to 4.5 percent at 30 years) than do the nominal rates (5.6 percent at 3 years to 6.8 percent at 30 years). The most likely reason for the apparent increase in real rates in the out years is that the public is using different assumptions about future inflation than the official assumption that OMB used to derive these rates. For this reason, the short-term real rates may be a better indicator of the rate of time preference (and actual Treasury borrowing costs) than are the longer term rates.

The BCM is designed to use a single real discount rate. At first glance it might seem that the 30-year rate is most appropriate, since a rehabilitated building should generally have an expected lifetime of 30 years or more. However, that conclusion is not correct since much of the value of a Treasury bond represents the face value at maturity, while a rehabilitation project produces returns beginning in the first year, with very little residual value at "maturity." Circular A-94 requires that the selected discount rate correspond to the cost of debt of "comparable maturity to the period of analysis."²⁴ Elsewhere it suggests a comparable "duration."²⁵ In the context of bonds and discount rates, duration is a term of art and is *not* synonymous with maturity—generally the duration of a note or bond will be slightly shorter than its maturity, because duration assigns a weight to all of the interim coupon payments the bondholder receives, as well as to the face value at maturity.

The difference between maturity and duration is even greater when dealing with building projects. A seismic rehabilitation project with a 30-year lifetime ("maturity") and little salvage value will have an effective "duration" of about 15 years. Thus, choosing

²⁴ Circular A-94 Section 8 C.(1).

²⁵ Circular A-94 Appendix C

a borrowing rate by matching durations will give about 4.3 percent.

The most accurate method of choosing a discount rate is a variation of the comparable duration method. The proper comparison is between the project in question and a *portfolio* of bonds of varying maturity, selected so that the cash flow of the portfolio matches that of the project.²⁶ Since the BCM uses level year-to-year estimates of earthquake risk and damage functions, the stream of expected benefits also is level.²⁷ To simulate this level cash-flow one would need a portfolio of both short and long-term Treasury securities. In choosing a single discount rate to approximate the rate of return of this portfolio, the short-term rates will count more heavily. This, together with the earlier observation about the effect of inflation on long-term rates, suggests tilting a bit more toward the shorter-term (i.e., lower) rates. The default discount rate in the BCM is 4 percent (corresponding to 7-year Treasury bonds) for the base case. Reasonable sensitivity analyses could use real discount rates as low as 2 percent and as high as 7 percent.

V. Summary of the Recommended Approach

Seismic rehabilitation of federal buildings is best evaluated as an internal government investment. Accordingly, the BCM uses a real risk-free discount rate of 4 percent for all costs and benefits, with no economic output multipliers, no excess-burden multiplier, and no multiplier for the shadow price of capital. The rationale for this approach is that almost all costs and benefits either represent federal expenditures, or are denominated in federal expenditure-equivalent dollars.

The only significant exception to this generalization is the value of life, which represents an external benefit denominated in private consumption-equivalent dollars. A literal interpretation of Circular A-94 would require that the value of life be deflated by a factor of 0.8, to account for the excess burden of taxes, and discounted at the higher 7 percent rate of return to private capital. However, the higher discount rate in this context is not supported by the literature on which Circular A-94 is based. Moreover, since the BCM is designed to produce sensitivity analyses that display the effect of a variety of assumptions about the value of life, *ad hoc* adjustments such as the excess burden multiplier would not add anything (except perhaps controversy) to the model.

²⁶ Geoffrey White, Treasury Department, private communication, 1993. (Mr. White did much of the research for revising Circular A-94 while at the Defense Department.)

²⁷ One component of the benefit stream, salvage value, can be anticipated to change from year-to-year but this will not have a large enough effect to skew the choice of discount rate.

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Appendix: Compliance Outline for Circular A-94

This section reprints language from Circular A-94. Commentary on the relevance of Circular A-94 language to the BCM is shown in bold italics.

Sections 1 - 4: Purpose, Rescission, Authority, and Scope

The goal of this Circular is to promote efficient resource allocation. It provides general guidance on benefit-cost analyses and specific guidance on discount rates. This guidance will serve as a “checklist” of whether an agency has considered and properly dealt with all of the elements for sound analyses.

It replaces OMB Circular A-94, Revised (dated March 27, 1972) and Circular A-104 (dated June 1, 1986). It is issued under the authority of 31 U.S.C. Section 1111 and the Budget and Accounting Act of 1921, as amended. It does not supersede agency practices which are prescribed by law, Executive Order, or other Circulars.

These guidelines must be followed in all analyses submitted to OMB, and are suggested for internal planning by agencies. Specifically exempted are water resource projects, acquisition of services under Circular A-76, and Federal energy management programs. This Circular applies to all agencies of the Executive Branch of the Federal Government.

Clearly most applications of the BCM will be subject to Circular A-94.

Section 5: General Principles

Benefit-cost analysis is recommended as the technique to use in formal economic analysis of Government programs or projects. The standard decision criterion is the net present value of benefits minus costs. Benefits and costs should always be enumerated, quantified where possible, and monetized where feasible. Cost-effectiveness analyses can be used where alternatives under consideration have the same stream of benefits.

The analysis should always include a statement of the policy rationale for Government action. Assumptions should be explicit; alternatives should be evaluated; results should be verified.

The BCM complies with these principles. The policy rationale is simply that the Government owns or operates many facilities and is the only entity that can make the necessary decisions about earthquake mitigation measures.

Section 6: Identifying and Measuring Benefits and Costs

Benefits and costs should be evaluated from the point of view of the United States as a whole (rather than of the Government narrowly). Only incremental benefits and costs (those affected by the decision) should be counted; sunk benefits and costs should be ignored, and pure transfers should be ignored.

Willingness-to-pay is the preferred measure of benefits and costs, and should be determined from market prices (corrected for any distortions), from hedonic prices, or from other market behavior. Inframarginal valuations (i.e., consumer surplus) should be estimated, since benefits will often take this form. Economic output multipliers should be avoided.

The BCM for federal buildings is broader than the version of the model for private buildings (FEMA 227, 228), in that it estimates benefits and costs from the point of view of society as a whole. Most estimates of benefits and costs are inferred from market prices; the value of life is derived from hedonic wage studies. The value of government services cannot be determined from market data; instead, the BCM uses quasi-willingness-to-pay estimates of value (see Chapter 2 of this volume). No output multipliers are used.

Section 7: Treatment of Inflation

OMB recommends the use of real monetary values and real discount rates in most analyses and recommends the GDP deflator to adjust for inflation when necessary.

The BCM uses real values and rates. See Section II. A. above.

Section 8: Discount Rate Policy

For public investments and for regulations, use a 7 percent real discount rate, with sensitivity analyses in both directions. Use a shadow price of capital only with prior OMB approval.

For lease-purchase analyses, use nominal Treasury borrowing rates found in Appendix C (reprinted on page 3-27).

For cost-effectiveness analyses, including internal government investments and government asset sales, use real Treasury borrowing rates, found in Appendix C.

The BCM most closely resembles an internal government investment, and uses a real Treasury borrowing rate as the discount rate. See Sections III. C. and IV. in the main body of this chapter. Also see Chapter 2 of this volume on valuing Government services.

Section 9: Treatment of Uncertainty

The sources and nature of uncertainty should be characterized (with probability distributions where possible), and the limitations it imposes on the analysis should be discussed. Net present values should use unbiased expected values for benefit and costs streams. Sensitivity analyses should be used to explore the properties of the analyses. Discount rates should not be adjusted to account for risky projects; rather, certainty-equivalent values should be used where necessary to adjust for risk-aversion or for risk correlation.

The BCM uses risk-free discount rates and best estimates of expected values for all variables that enter into the model; sensitivity analyses are used to reveal the effect of assumptions on the model's output. See Section II. B. in the main body of this chapter.

Section 10: Incidence and Distribution Effects

Since both benefits and costs are largely on the federal budget, incidence and distribution effects are not expected to be important for the BCM model.

Section 11: Special Guidance for Public Investment Analysis

Analyses of public investments should include a supplementary analysis using an excess burden of 25 cents per dollar of revenue, applied to all public expenditures.

This Section has limited applicability because earthquake mitigation measures are best treated as internal government investments, with few external benefits. Estimates of the value of lost services already reflect the excess burden of taxation, because of the nature of the quasi-willingness-to-pay methodology. (See Chapter 2 of this volume.) Estimates of the value of life do not reflect the excess burden of taxation, but sensitivity analyses will encompass any effect this adjustment could have on the BCM's output. (See Section III. B. in the main body of this chapter.)

Section 12: Special Guidance for Regulatory Impact Analysis

Additional guidance for analysis of regulatory policies is provided in the *Regulatory Program of the United States Government*, which is published annually by OMB. (See "Regulatory Impact Analysis Guidance," Appendix V of *Regulatory Program of the United States Government* for April 1, 1991, to March 31, 1992.)

This section will not apply to the BCM unless it is used to develop

regulations that prescribe seismic rehabilitation of federal buildings. In any event, the BCM is expected generally to be in compliance with the OMB's guidance for RIAs.

Section 13: Special Guidance for Lease-Purchase Analysis

Not applicable to the BCM.

Sections 14-15: Related Guidance, and Implementation

Contains a list of related OMB Circulars and other guidelines; and specifies that implementation of Circular A-94 will be enforced through the procedures outlined in Circular A-11, *Preparation and Submission of Annual Budget Estimates*, and Circular A-19, *Legislative Coordination and Clearance*.

Section 16: Effective Date

This Circular is effective immediately.

Section 17: Interpretation

Questions concerning interpretation of this Circular should be addressed to the Office of Economic Policy, Office of Management and Budget (202-395-5873) or, in the case of regulatory issues and analysis, to the Office of Information and Regulatory Affairs (202-395-4852).

Circular A-94 Appendices

Appendix A: Definition of Terms

Reprinted in its entirety below.

Appendix B: Additional Guidance for Discounting

Contains a sample format for discounting analyses; a conversion ratio between end-of-year and mid-year discount factors; and a table of illustrative discount factors.

Appendix C: Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses.

Reprinted in its entirety below.

Definition of Terms Circular A-94, Appendix A

Benefit-Cost Analysis — A systematic quantitative method of assessing the desirability of Government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects.

Capital Asset — Tangible Property, including durable goods, equipment, buildings, installations, and land.

Certainty-equivalent — A certain (i.e., nonrandom) outcome that an individual values equally to an uncertain outcome. For a risk-averse individual, the certainty-equivalent for an uncertain set of benefits may be less than the mathematical expectation of the outcome; for example, an individual may value a 50-50 chance of winning \$100 or \$0 as only \$45. Analogously, a risk-averse individual may have a certainty equivalent for an uncertain set of costs that is larger in magnitude than the mathematical expectation of costs.

Cost-Effectiveness Analysis — A systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective.

Consumer Surplus — The maximum sum of money a consumer would be willing to pay to consume a given amount of a good, less the amount actually paid. It is represented graphically by the area between the demand curve and the price line in a diagram representing the consumer's demand for the good as a function of its price.

Discount Rate — The interest rate used in calculating the present value of expected yearly benefits and costs.

Discount Factor — The factor that translates expected benefits or costs in any given future year into present value terms. The discount factor is equal to $1/(1 + i)^t$ where i is the interest rate and t is the number of years from the date of initiation for the program or policy until the given future year.

Excess Burden — Unless a tax is imposed in the form of a lump-sum unrelated to economic activity, such as a head tax, it will affect economic decisions on the margin. Departures from economic efficiency resulting from the distorting effect of taxes are called excess burdens, because they disadvantage society without adding to Treasury receipts. This concept is also sometimes referred to as deadweight loss.

External Economy or Diseconomy — A direct effect, either positive or negative, on someone's profit or welfare arising as a byproduct of some other person's or firm's activity. Also referred to as neighborhood or spillover effects, or externalities for short.

Incidence — The ultimate distributional effect of a tax, expenditure, or regulatory program.

Inflation — The proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price. Inflation is usually measured by a broad-based price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

Internal Rate of Return — The discount rate that sets the net present value of the stream of net benefits equal to zero. The internal rate of return may have multiple values when the stream of net benefits alternates from negative to positive more than once.

Life Cycle Cost — The overall estimated cost for a particular program alternative over the time period corresponding to the life of the program including direct and indirect initial costs plus any periodic or continuing costs of operation and maintenance.

Multiplier — The ratio between the direct effect on output or employment and the full effect, including the effects of second order rounds of spending. Multiplier effects greater than 1.0 require the existence of involuntary unemployment.

Net Present Value — The difference between the discounted present value of benefits and the discounted present value of costs.

Nominal Values — Economic units measured in terms of purchasing power of the date in question. A nominal value reflects the effects of general price inflation.

Nominal Interest Rate — An interest rate that is not adjusted to remove the effects of actual or expected inflation. Market interest rates are generally nominal interest rates.

Opportunity Cost — The maximum worth of a good or input among possible alternative uses.

Real or Constant Dollar Values — Economic units measured in terms of constant purchasing power. A real value is not affected by general price inflation. Real values can be estimated by deflating nominal values with a general price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

Real Interest Rate — An interest rate that has been adjusted to remove the effect of expected or actual inflation. Real interest rates can be approximated by subtracting the expected or actual inflation rate from a nominal interest rate. (A precise estimate can be obtained by dividing one plus the nominal interest rate by one plus the expected or actual inflation rate, and subtracting one from the resulting quotient.)

Relative Price — A price ratio between two goods as, for example, the ratio of the price of energy to the price of equipment.

Shadow Price — An estimate of what the price of a good or input would be in the absence of market distortions, such as externalities or taxes. For example, the shadow price of capital is the present value of the social returns to capital (before corporate income taxes) measured in units of consumption.

Sunk Cost — A cost incurred in the past that will not be affected by any present or future decision. Sunk costs should be ignored in determining whether a new investment is worthwhile.

Transfer Payment — A payment of money or goods. A pure transfer is unrelated to the provision of any goods or services in exchange. Such payments alter the distribution of income, but do not directly affect the allocation of resources on the margin.

Treasury Rates — Rates of interest on marketable Treasury debt. Such debt is issued in maturities ranging from 91 days to 30 years.

Willingness to Pay — The maximum amount an individual would be willing to give up in order to secure a change in the provision of a good or service.

**Discount Rates for Cost-Effectiveness,
Lease Purchase, and Related Analyses
Circular A-94 (rev. 10/29/92), Appendix C (rev. 2/25/93)**

Effective Dates. This appendix is updated annually around the time of the President's budget submission to Congress. This version of the appendix is valid only through February, 1994. Updates of this appendix will be available upon request from the Office of Economic Policy in OMB (202-395-3381). Copies of the appendix and the Circular may also be obtained from the OMB Publications Office (202-395-7332).

Nominal Discount Rates. Nominal interest rates based on the economic assumptions from the budget are presented in the table below. These nominal rates are to be used for discounting nominal flows, as in lease-purchase analysis

Nominal Interest Rates on Treasury Notes and Bonds
of Specified Maturities (in percent)

<u>3-year</u>	<u>5-year</u>	<u>7-year</u>	<u>10-year</u>	<u>30-year</u>
5.6	6.0	6.3	6.7	6.8

Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three-year and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.

Real Discount Rates. Real interest rates based on the economic assumptions from the budget are presented below. These real rates are to be used for discounting real (constant-dollar) flows, as in cost-effectiveness analysis.

Real Interest Rates on Treasury Notes and Bonds
of Specified Maturities (in percent)

<u>3-year</u>	<u>5-year</u>	<u>7-year</u>	<u>10-year</u>	<u>30-year</u>
3.1	3.6	4.0	4.3	4.5

Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three-year and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.